Before proceeding further it must be remarked that in fig. 40, Plate II, we have given the color black, which plays such a conspicuous part in the glyph, fig. 36, the phonetic value of *ek* or *ik*. It frequently appears witn these phonetic values in Maya script, and it is my opinion that red may also have the phonetic value of *Chac*, cha v/s, yellow *Kan*, ka v/s, and green *xan*, *xa* v/s. It will be impossible to discuss the subject here; we leave the suggestion to time to decide, but attention is called to the fact that color seems to be ikonomatic in Maya script. Above the *ideo-phonetic* figure in Plate 17, Peresianus, (a compound of ideographic suggestion and phonetic elements), is a series of glyphs whose analyses are made on Plate II, figs. 41 to73. It will be observed that many of the phonetic values assigned by me to certain phonetic elements are being repeated in new combinations with probable results. The interpretation given is *u-chak Kukulkan*, *chakikal*, *Chakanik*. There are two more glyphs in this series on Plate 17 (Peresianus), but as they are somewhat erased it would be necessary to compare them with others on Plates 15, 16. 18, (Peresianus), and other parts of this codex, which is here impossible. The series of glyphs on all of the plates referred to, viz.: 15, 16, 17, 18 (Peresianus), read from the lower right hand glyph toward the left, thus:

F. E
D. C
B A

and repeat name of *Kukulkan* with reference to his title of God of Wind and ruler of the cardinal points. The order of repetition of the words given by the glyphs varies in some of the plates. The series is in fact a repetition of the compound glyph of the Peresianus, as shown in my plate, fig. 21, with the addition of the title *Chakikal*, thus: *Bacab*, *xakan ik*, *Chakikal* = "Ruler of the Cardinal Points, God of Wind." (*Bacab* = ruler, xakan-ik = the "cardinal points" or the winds that revolve around it; *Chak* = "God," *ik* = "wind," or this latter may be read = "hurricane.")

Especial attention is called to the glyph fig. 45 in this series, where three *Kan* glyphs express the name *Kukulkan*, their different phonetic values being indicated by the small *phonetic additions* attached to the top of the glyphs inside of its enclosing circle, see figs. 45, 46, 47, 48, 49, 50, 51. The name of *Kukulkan* is also repeated on Plate 23, Peresianus; three *Cauac* glyphs being used, their values being changed by the phonetic additions attached. See figs. 235, 236, 238, 239, Plate II.

Fig. 73 is a well-known glyph in the Peresianus. It has been designated by me the Chak glyph from the fact that the phonetic elements within it express that word and the figures attached to the glyphs in the Peresianus, there is good reason to think, are *chaks* or *bacabs*, supporting my analysis of its phonetic elements. The phonetic elements of which it is composed are frequently repeated in Maya script and are among the most primitive of those represented in Part I of this article, published in *Science*, No. 567.

A repetition of the title Bacab-xakanik, with the yellow color appearing with phonetic value, is given in the series, Plate II, figs. 80 to 84*a*, taken from Plate 16, Peresianus. See also series figs. 85 to 101. The glyph fig. 102 my analysis indicates to be that of *u Hoobnil-Kan*. The dotted aspirate circle, fig. 104, gives *Ho*, derived from the phonetic value of *cho* or *sho*, *xo* v/s. The square, fig. 105, encloses the same elements that are found in the day sign *Chuen*, and its phonetic value *cha* is indicated by the square in which it is enclosed—the square, generally, being associated with á, *Ka* v/s, sounds. If the same elements referred to were in a circle they would probably be *cho* or *chu*, as the circle is intimately associated with i, o, u, *ch*, *ik* sounds. The square and circle are probably vowel elements; see Article I, Plate I, figs 27, 43.

## NOTES ON THE GENUS STROMATOCERIUM.

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One wishing to recall the typical form of the genus *Stromatocerium* turns to Hall's monumental work, "Palæontology of New York," and in Vol. I., p. 48, finds the description of this well-marked genus. The horizon of *Stromatocerium rugosum* is that of the rocks of the lowest member of the Trenton period, that is, the Black River. This fossil is accepted as a guide in determining the rocks of that epoch.

That this form should flit across one geological horizon, should come and go, having no ancestry and leaving no descendants, seems strange. But this sudden appearance and disappearance is more apparent than real. It may not be possible to trace exact lineage, but likenesses and relationships are quite evident. The relatal forms are *Cryptozoon* below and *Stromatopora* above. It is true these are somewhat widely separated, both by structure and by stratigraphical position. Yet in general structure they are so alike that one has often been mistaken for the other.

We may briefly consider the stratigraphical relation of the *Stromatocerium* to the *Cryptozoon* in the rocks lying below. Immediately beneath the Black River is the Chazy, the rocks of which at their best estate have a thickness of near 900 feet. Beneath the Chazy lies the Calciferous, with its distinct divisions of rocks, the formation having a thickness of near 2,000 feet.

The rocks of these two epochs bordering Lake Champlain and filling so great part of the valley between the Green Mountains and the lake have a recognized likeness. Had not the name, Champlain, been preoccupied, this term could have been applied with appropriateness to the time period which would be constituted of the two epochs, Coazy and Calciferous.

The Chazy rocks may be looked upon as a wedge separating the Calciferous from the Black River rocks. The edge of this wedge in some places thins down and disappears, so the Black River is let down in contact with the Calciferous. The stratigraphical separation between the *Cryptozoon* and the *Stromatocerium* thus becomes zero.

So far as horizon is concerned the Cryptozoon may have clambered up into the Black River rocks. But the piling up of a little less than a thousand feet of Chazy rock, mostly calcareous, indicates the passage of a long interval of time. The sponge-like forms of the Chazy are not *Cryptozoa*. The concentric structure has been retained by several, yet they are clearly distinguishable from that fossil. One of the most noticeable of these forms is a *Stromatocerium*.

The genus as characterized by Professor Hall may admit of considerable variation, yet these Chazy forms in all essentials correspond to the type. They differ, however, from *Stromatocerium rugosum*, and so widely do they diverge that the difference can hardly be less than specific. They have been studied with some care and specific names applied, but a general statement of position and character will be enough for the present.

The divisions of the Chazy rocks may be properly designated from below upward A, B, C. Distinct forms of *Stromatocerium* are found in each. That found in A, the lowest division, has a growth in shape and sometimes in size like the old-time straw bee hive. It appears in B but somewhat modified in form. The special form in B is peculiar in growth and massiveness. The fossil is made up of a series of corrugations, these being from a quarter of an inch to a half inch in height. Blocks three feet by eight lifted from the quarry are sometimes made up mostly of this form. In division C are several forms; a noticeable one has its fresh surface covered with mastoidal eminences; these when cut down by weathering leave a series of beautiful rings or concentric circles. Examples of this species are not unlike an inverted saucer in shape.

The species found in A may be collected at Chazy, N. Y., and at many localities in Vermont; those in B and C at their appropriate horizons at Isle La Motte, Vt. The form in B is incidentally largely distributed through the country and will be found when looked for in the tiled floors of almost every public building where Isle La Motte marble has been used. In museums, too, it will be found under title of "Isle La Motte banded limestone." The place above all others for display of *S. vagosum* is a little island, at the entrance of Button Bay, three miles south of Fort Cassin, Vt., where a layer 20 to 30 inches thick is exclusively of this form and *Columnavia alveolata*, *H.*

The following facts are evident: (1) the genus *Stromatocerium* does not make its first appearance in the Black River; it is there rather in its decadence; (2) it appears in the lower Chazy, following close upon the *Cryptozoon*, and persists through the different divisions; (3) it cannot of itself be trusted as a safe indication of the Black River.

However, it should be noticed that *Stromatocerium vagosum* is most frequently paired with *Columnaria alveolata*, and the presence of the two forms establishes beyond question the presence of the Black River.

## DR. CALLAWAY AND THE PRODUCTION OF CRYSTALLINE SCHISTS BY DYNAMO-METAMORPHISM.

BY J. W. REDWAY, F.R.G.S., MT. VERNON, N.Y.

About fifteen years ago, while setting a piece of heavy mining machinery that revolved on a vertical shaft, work was brought to a stand by the discovery that the journal, intended as a chair and box for the cone-shaped bearing, was considerably too small. A speculative workman thought it might wear down to shape, however, and started the machinery. The experiment, though of doubtful success from a mechanical standpoint, was brilliantly successful in another light. The bearing and journal, both of drop-forged steel, were welded to each other and broke into a dozen pieces. The interesting point, however, was the fact that two forgings of laminated steel under the agency of heat were converted to a metamorphic form. At the surface of welding the laminated steel became crystalline, and even the parts at some distance became semi-crystalline. It was a fair illustration of what is now called dynamo-metamorphism.

In a very remarkable paper presented to the *Quarterly Journal* of the Geological Society of England, Mr. Charles Callaway, D. Sc., F.G.S., has published the result of his researches on the origin and formation of certain crystaline schists found in the Malvern Hills, in the west of England. A close study of these schists during a period of five years has brought Dr. Callaway to the conclusion that they were produced by a dynamo-metamorphosis not different in essential principles from the illustration described in the preceding paragraph. Ordinarily, metamorphism in rocks may be briefly described as the change that a sedimentary rock undergoes when subjected to intense pressure in the presence of heat and moisture. The rock becomes more or less crystalline, and there is a tendency from homogeneity to heterogeneity in mineral structure. The production of metamorphism by the shearing of rock and the gradual sliding or movement of the one mass upon the surface of the other is called dynamo-metamorphism. Neither the name nor the idea originated with Dr. Callaway, but the thorough exposition the subject has received at his hands entitles him to a foremost place among the pioneers in this field of research, and the results he has obtained are an important step in advance in the field of dynamic geology.

The Malvern Hills are mainly composed of masses of igneous rock, granitic in character, the constituents chiefly considered being binary granite and two kinds of dorite. In certain localities there are exposed bands of crystalline schist, apparently as seams of subsequent intercalation but really cataclastic in origin. These seams are the shear-zones within which the schist-making process occurred. Aside from the normal metamorphism which took place, the chief factor seemed to be a distinct shearing movement that resulted in a fusion sufficiently complete to produce plasticity.

Among the mechanical changes was the transformation of diorite into mica-gneiss. In the process of transformation the pulverized mineral not infrequently passed through an intermediate stage of laminated grit that simulated a sediment. A still more interesting change was the injection of potash and potassium feldspar into diorite, and a similar transference of the corresponding sodium salts into granite. In still other cases, diorite and granite were mutually interlaced. Chlorite and ferric oxide produced by the decomposition of diorite were injected or infiltrated into the cracks, cleavage and shear-planes of crushed granite and often migrated to a considerable distance, giving rise to an interfoliation of chlorite and biotite with the quartz, feldspar, and muscovite of the resulting gneiss.

The mineral changes may be classified as (*a*) decomposition, (*b*) transition, and (*c*) reconstruction. The massive rocks pass into schists through a process of decomposition, followed and partly accompanied by a process of reconstruction, in which the newly-formed quartz and feldspar crystallize, after the secondary consolidation. The chief mineral changes of the schist-making process are (*a*) the replacement of orthoclase by quartz and muscovite; (*b*) of plagioclase by the quartz and muscovite; (*c*) of chlorite by biotite and white mica; (*d*) and of biotite by white mica. The liberation of potassium from the granite is sometimes accompanied by silicification of the veins and the production of garnets. The reconstruction of feldspar is also a prominent feature in the metamorphism.

Among the chemical changes the following are noteworthy: (*a*) the mutual transference of sodium and potassium compounds between diorite and granite, also previously noted among physical changes; (*b*) the removal of sodium, potassium, magnesium, calcium, aluminium and iron compounds when diorite is converted to gneissoid quartzite; (*c*) the retention of aluminium and the elimination of alkaline compounds when diorite is metamorphosed to muscovite.

Dr. Callaway's researches involved the preparation of about 500 thin sections of rock for study with the microscope, and a large number of chemical analyses. His hypotheses are bold and ingenious, involving metasomatosis on a large scale. Subsequent investigations, however, have not disproved them; on the contrary they have been strongly confirmed. It is interesting, moreover, to compare the work of Dr. Callaway with that of Mr. Van Hise on the schists of the Penokee iron-bearing series (U. S. Geol. Survey, Rep. 1888 and 1889, pp. 429 et seq.). The ideas shadowed in Mr. Van Hise's report could not have been more fully confirmed than they have been by Dr. Callaway, working independently at the same time on rocks several thousand miles away.